Solar Energy and Color

Student Objective
The student:
- will be able to explain the effect the color of an object has on the amount of solar thermal energy absorbed
- given a situation will be able to pick which color will absorb less solar energy and therefore remain cooler, and which will absorb more solar thermal energy
- will understand some uses of solar thermal energy for meeting the energy needs of the world.

Key Words:
color
heat
solar thermal energy

Time:
½ hour

Materials (for each group):
- 1 plastic bottle painted white
- 1 plastic bottle painted black
- balloons (3 of the same color for each group)
- Science Discovery Sheet

Background Information

The different colors of visible light have different wavelengths. Violet light has the shortest wavelength, has the most energy, and is closest to ultraviolet light. Red light has the longest wavelength, has less energy, and is closest to infrared light. The other colors of visible light increase in wavelength and decrease in energy as they get closer to red and infrared light.

When you shine white light or sunlight on a colored object, the object will appear to be the color of the light it reflects; in the case of white it is reflecting all of the colors, while black is reflecting none. The other visible wavelengths (colors) are absorbed and we don't see them. Lighter colors reflect more light; darker colors absorb comparatively more light. Since light is energy, an absorption would increase a material's temperature. It is conventionally said that red and orange are 'warm' colors while blue and violet are called 'cool' colors, but this describes the way people feel when they look at colors, and has nothing to do with the abilities of different colors to warm things up. Actually, a photon traveling in a blue wavelength contains more energy than one traveling in a red wavelength, and so if totally absorbed it would be converted into more heat.

Naturally there are gradients of color and therefore gradients of absorption. So too, the type of material will affect its relative heating. In this experiment, the deciding factor is how much light is absorbed, how much is reflected, and how much is radiated away. The darker the

color, the less visible light it is reflecting and the more it is absorbing. The absorbed light is converted to heat.

Procedure

1. This experiment should be done outside on a sunny day.
2. Explain the procedure to the class:
   - each group will have a black and a white bottle
   - a balloon will be placed over the top of each bottle
   - the bottles will then be placed in the sun
3. Discuss with the students the hypothesis of the results.
4. Divide the class into groups of two or three students.
5. Hand out the bottles so that each group has a black bottle and a white bottle. Help the students as necessary to set up their experiments.
6. Place the bottles in a sunny area. They should be placed close together, but not shading each other.
7. Students should observe what happens to the balloons over a period of time. *(Within a few minutes the balloon attached to the black bottle will begin to inflate slightly. The balloon attached to the white bottle will remain limp.)*
8. Have the students touch each bottle and compare how they feel. *(The black bottle will be warmer than the white bottle.)*
9. Lead the class in a discussion of what is occurring. Direct the discussion toward heat and solar energy. Possible points to discuss:
   - What color would be the best for a solar collector that heats water such as a solar pool heater or water heater?
   - What color roof would be the best for a house in Florida that you are trying to keep cool?
10. Have the students complete the Science Discovery Sheet. Instruct them to color the house. The roof should be a color that would be good for a Florida house to remain cool in the summer, and the solar collector should be a good color for collecting heat.

Key Words and Definitions

- **color** - the aspect of things that is caused by differing qualities of the light reflected
- **heat** - a form of energy associated with the motion of atoms or molecules and capable of being transmitted through solid and fluid media by conduction, through fluid media by convection, and through empty space through radiation. Heat is the transfer of energy from one body to another as a result of a difference in temperature or a change in phase.
- **solar thermal energy** - energy derived from the sun to heat something. Common uses include water heaters and pool heaters.

Further Activities

1. You are designing a public park in a local desert community to include a playground, benches, and picnic tables. The theme of the park requires a variety of colors. What colors

should you choose to ensure that the benches and tables can be usable on hot summer days. Explain your reasoning.

2. Suppose your friends offered you sodas in blue, yellow, and white colored cans that had been sitting in sunlight for a half hour. Which color would you choose if you want the coolest drink? Which would you stay away from because it might be too warm to drink? Design an experiment that would test your hypothesis.

Related Reading

- ***Sun*** by Steve M. Tomecek (National Geographic Society, 2001)
  This book follows two kids and a purple cat as they learn about sunspots and solar flares, see how the Sun creates night and day and the seasons, and learn how the Sun warms the Earth. Also included is Earth's place in the solar system, scientists studying the Sun through special telescopes, and the bounty of life on Earth nurtured by the heat-giving rays of our star.

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Florida NGSS Standards & Related Subject Common Core

			.1	.2	.3	.4	.5	.6
Grade K								
The Practice of Science	**Big Idea 1**	**SC.K.N.1**	**X**	**X**			**X**	
Properties of Matter	**Big Idea 8**	**SC.K.P.8**	**X**					
Grade 1								
The Practice of Science	**Big Idea 1**	**SC.1.N.1**	**X**					
Earth in Space and Time	**Big Idea 5**	**SC.1.E.5**				**X**		
Properties of Matter	**Big Idea 8**	**SC.1.P.8**	**X**					
Grade 2								
The Practice of Science	**Big Idea 1**	**SC.2.N.1**	**X**					
Earth Systems and Patterns	**Big Idea 7**	**SC.2.E.7**		**X**				
Properties of Matter	**Big Idea 8**	**SC.2.P.8**	**X**					
Language Arts Standards	**Kindergarten:** LAFS.K.W.3.8, LAFS.K.SL.1.1 **First Grade:** LAFS.1.W.3.8, LAFS.1.SL.1.1 **Second Grade**: LAFS.2.W.3.8, LAFS.2.SL.1.1							
Mathematics Standards	**Kindergarten:** MAFS.K.MD.1.2							

Kindergarten Benchmarks

Science--Big Idea 1: The Practice of Science

- SC.K.N.1.1 - Collaborate with a partner to collect information.
- SC.K.N.1.2 - Make observations of the natural world and know that they are descriptors collected using the five senses.
- SC.K.N.1.5 - Recognize that learning can come from careful observation.

Science--Big Idea 8: Properties of Matter

- SC.K.P.8.1 - Sort objects by observable properties, such as size, shape, color, temperature (hot or cold), weight and texture.

Language Arts–Writing

- LAFS.K.W.3.8 - With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Language Arts–Standards for Speaking and Listening

- LAFS.K.SL.1.1 - Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups.

Mathematics–Measurement and Data

- MAFS.K.MD.1.2 - Directly compare two objects with a measurable attribute in common, to see which object has 'more of' / 'less of' the attribute, and describe the difference.

First Grade Benchmarks

Science–Big Idea 1: The Practice of Science

- SC.1.N.1.1 - Raise questions about the natural world, investigate them in teams through free exploration, and generate appropriate explanations based on those explorations.

Science–Big Idea 5: Earth in Space and Time

- SC.1.E.5.4 - Identify the beneficial and harmful properties of the Sun.

Science–Big Idea 8: Properties of Matter

- SC.1.P.8.1 - Sort objects by observable properties, such as size, shape, color, temperature (hot or cold), weight, texture and whether objects sink or float.

Language Arts–Writing

- LAFS.1.W.3.8 - With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Language Arts–Standards for Speaking and Listening

- LAFS.1.SL.1.1 - Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

Second Grade Benchmarks

Science–Big Idea 1: The Practice of Science

- SC.2.N.1.1 - Raise questions about the natural world, investigate them in teams through free exploration and systematic observations, and generate appropriate explanations based on those explorations.

Science–Big Idea 7: Earth Systems and Patterns

- SC.2.E.7.2 - Investigate by observing and measuring, that the Sun's energy directly and indirectly warms the water, land, and air.

Science–Big Idea 8: Properties of Matter

- SC.2.P.8.1 - Observe and measure objects in terms of their properties, including size, shape, color, temperature, weight, texture, sinking or floating in water, and attraction or repulsion of magnets.

Language Arts–Writing

- LAFS.2.W.3.8 - Recall information from experiences or gather information from provided sources to answer a question.

Language Arts–Standards for Speaking and Listening

- LAFS.2.SL.1.1 - Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.

National Next Generation Science

Kindergarten Standards
Science–Energy
- K-PS3-1 - Make observations to determine the effect of sunlight on Earth's surface.

Note: Related Common Core Mathematics and Language Arts Standards are listed in the Florida section above.

First Grade Standards
Science–Waves and their Applications in Technologies for Information Transfer
- 1-PS4-3 - Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

Note: Related Common Core Language Arts Standards are listed in the Florida section above.

Second Grade Standards
Science–Matter and its Interactions
- 2-PS1-1 - Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- 2-PS1-2 - Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Note: Related Common Core Language Arts Standards are listed in the Florida section above.

Solar Energy and Color

This house has a roof that helps keep it cool. The solar collector heats water for the house.